## CLAIMS

1. A method for providing rotational leg control during a swing phase of a robotic locomotion device, the method comprising:

computing an apex height return map of two consecutive flight phases for different angles of attack;

selecting all pairs of leg angle and apex heights that result in a desired apex height of a next consecutive flight phase;

for each leg angle-apex height pair, computing the corresponding flight times from apex to touch-down; and

storing dependencies between flight time after apex and leg angle for any desired consecutive apex heights.

2. The method of claim 1 further comprising determining an instant of apex during flight phase by a vertical take-off velocity.

3. The method of claim 2 further comprising controlling the angular leg orientation using the stored time dependencies for a desired apex height.

4. The method of claim 3 wherein controlling the angular leg orientation begins starting at apex.

5. The method of claim 1 wherein computing an apex height return map of two consecutive flight phases for different angles of attack comprises computing a distinct map for each of a plurality of different mechanical energy levels.

6. The method of claim 4 wherein controlling the angular leg orientation using the stored time dependencies for the desired apex height starting at apex, includes controlling the angular leg orientation such that the leg will reach the next apex in response to the leg contacting a surface at any time before or after an expected time.

7. The method of claim 4 further comprising at least one of: protracting the leg after the time to apex and retracting the leg after the time to apex.

8. The method of claim 3 wherein controlling the angular leg orientation includes moving the leg to a desired leg orientation at time to apex.

9. The method of claim 8 wherein controlling the angular leg orientation begins starting at apex.

10 A method of moving a leg of a robotic system, the method comprising:

determining a time to apex;

selecting an angle of attack based upon time after apex; and

providing rotational leg control continuously during the time after apex until touch-down occurs such that the leg is at a desired angle of attack when touch-down occurs.

11 The method of Claim 10 wherein determining a time to apex comprises computing a time series.

12. The method of Claim 10 wherein selecting an angle of attack based upon time after apex comprises retrieving an angle of attack from a lookup table based upon time after apex.

13. The method of Claim 12 further comprises providing a lookup table having stored therein values corresponding to a mapping of apex heights of two consecutive flight phases for different angles of attack.

14. The method of Claim 13 wherein providing a lookup table comprises providing a lookup table having stored therein a map of apex heights of two consecutive flight phases for different angles of attack for one or more mechanical energy levels of the robotic system.

15. The method of Claim 10 further comprising providing a lookup table that projects all possible apex heights to a desired apex height in a next flight phase.

16. The method of Claim 15 further comprising selecting the desired apex height.

17. The method of Claim 16 wherein providing rotational leg control comprises providing rotational leg control starting at apex.

18. The method of claim 10 wherein determining a time to apex comprises:
computing a vertical take-off position; and
computing a vertical velocity at take-off from leg angle and leg length.

19. The method of claim 18 further comprising:
using the time to apex to determine an angle of attack in a lookup table that associates a mapping of the apex height to the desired apex height with the angle of attack.

20. The method of claim 18 further comprising:
computing the angle of attack from the computed apex height and desired apex height.

21. The method of Claim 20 further comprising:
computing a vertical position and velocity at take-off from the leg angle and leg length;
computing an instant of apex within the flight phase from the vertical velocity at take-off;
computing mechanical system energy at take-off from the horizontal and vertical velocity at take-off and the vertical position at take-off; and
using the mechanical system energy at take-off and the instant of apex to determine a continuous adjustment in leg rotation that produces the angle of attack.

22. A robot comprising:
a body;
a leg coupled to the body;
a sensor, coupled to the leg, to provide a control signal indicating detection of a contact phase of the leg;
a sensor, coupled to the body and the leg, to provide a control signal indicating the leg orientation;

a sensor, coupled to the leg, to provide a control signal indicating the leg length;

a controller, coupled to the body and responsive to the control signals, to determine for a next contact phase an angle of attack to reach a desired apex height in a flight phase following the next contact phase; and

an actuator, coupled to the controller and the leg, to adjust orientation of the leg during a flight phase occurring between the contact phase and the next contact phase to achieve the angle of attack.

23. The robot of Claim 22 further comprising a memory, coupled to the controller, said memory having stored therein values corresponding to dependencies between flight time after apex and leg angle for any desired consecutive apex heights.

24. The robot of claim 23 wherein said controller controls the angular leg orientation by retrieving stored time dependency values for a desired apex height from said memory.

25. The method of claim 24 wherein said controller begins controlling the angular leg orientation starting at apex.

26. The robot of Claim 25 wherein the values stored in the lookup table correspond to values for a given system energy.

27. A method for providing rotational leg control during a swing phase of a robotic locomotion device, the method comprising:

identifying kinematic control elements of the leg;

identifying energetic control elements of the leg; and

separating the kinematic control elements of the leg from the energetic control elements of the leg.

28. The method of Claim 27, further comprising:

determining an energetic control level of the leg to control system energy within the robotic locomotion device; and

determining a kinematic control level of the leg to provide a desired energetically possible movement trajectory within one step.